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Valuation of Marine Ecosystem Threshold Effects: Application of Choice Experiments to Value Algal Bloom in the Black Sea Coast of Bulgaria

Tim Taylor* and Alberto Longo^

*Department of Economics and International Development, University of Bath, UK

^Queens University, Belfast, UK

Abstract

Algal bloom arises in part from anthropogenic emissions of nutrients into the coastal zone. Increased interest in water quality in coastal and marine areas stemming from the Water Framework Directive and the Marine Strategy Framework Directive leads to important questions in terms of policies to address nutrient loadings. This paper presents the results from a choice experiment for the valuation of algal blooms in Varna Bay, Bulgaria. Varna Bay is an important tourist destination and a large port city on the Black Sea coast of Bulgaria. Algal bloom events have been experienced frequently in this area. A choice experiment questionnaire was developed to be applied in Varna Bay. The key attributes used were visibility, duration of bloom and the amount of congestion on the beach. The amount of bloom is found to be important: respondents are willing to pay for a program that entails 1 week of algal bloom about 33 Leva (s.e. 8.09) when there is high visibility; 21 Leva (s.e. 5.75) with medium visibility and 9 Leva (s.e. 3.48) with low visibility. Respondents are willing to pay more for programs that offer shorter duration of algal bloom. The marginal price for one metre of extra space between the respondent and the nearest person is equal to 0.38 Leva.

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Introduction

The potential for threshold effects in marine ecosystems has been the subject of much research in recent years. One impact of nutrient loadings in marine ecosystems is that of algal blooms. Algal bloom has a number of significant impacts, including potential impacts on fisheries, on biodiversity and on water clarity. The latter has potentially significant values in terms of recreation and amenity.

Algal blooms have been experienced in the Black Sea coast as a result of nutrient inputs. In this paper, we focus on the case of Varna Bay, Bulgaria. Varna Bay is an important coastal resort, with the main sources of nutrients being waste water treatment, agriculture and industry. The algal bloom in Varna is not toxic, and so the main impacts are on recreation and amenity in terms of reduced visibility in the coastal waters. We focus on values placed on visibility in coastal waters by local residents. This in part is due to the fact that previous studies (e.g. ECOHARM) have examined the values of tourists, and due to the difficulties in designing incentive-compatible payment vehicles for tourists.

The paper is structured as follows. First an overview of Varna Bay is presented, along with an overview of the major issues in terms of algal blooms in the area. Then an overview of previous studies to value algal blooms is presented. The choice experiment methodology is then applied to the particular case of algal blooms, and the design of the questionnaire is presented. The results are then discussed and conclusions presented.

Varna Bay - Overview

Varna Bay is an important coastal resort on the Black Sea coast of Bulgaria. It is located south of the Danube delta. The largest tourist resort on the Bulgarian coast, it faces significant environmental pressures (Ketsetzopoulou and Moncheva, undated). The Varna Bay area has been the subject of a number of algal bloom events in recent history. In the period 1983 to 2002 there were 117 incidents of bloom, with 7 incidents of bloom in 2001. A number of species are responsible for the bloom, with in recent history *Skeletonema costatum*, *Cerataulina pelagica*, *Prorocentrum minimum* and *Gymnodinium sp* being species responsible for bloom events (Moncheva, 2006). This variation in species underlies the difficulty in managing complex ecosystems, with factors such as timing in the year, temperature and other causal factors affecting type and quantity of bloom – it is important to note that nutrient levels are only one factor among many affecting bloom quantity and duration. The watershed is shown in Figure 2 below, showing a river which outputs into the bay and a small lake which is host to a waste water treatment plant.

Figure 2: Varna Bay and Catchment

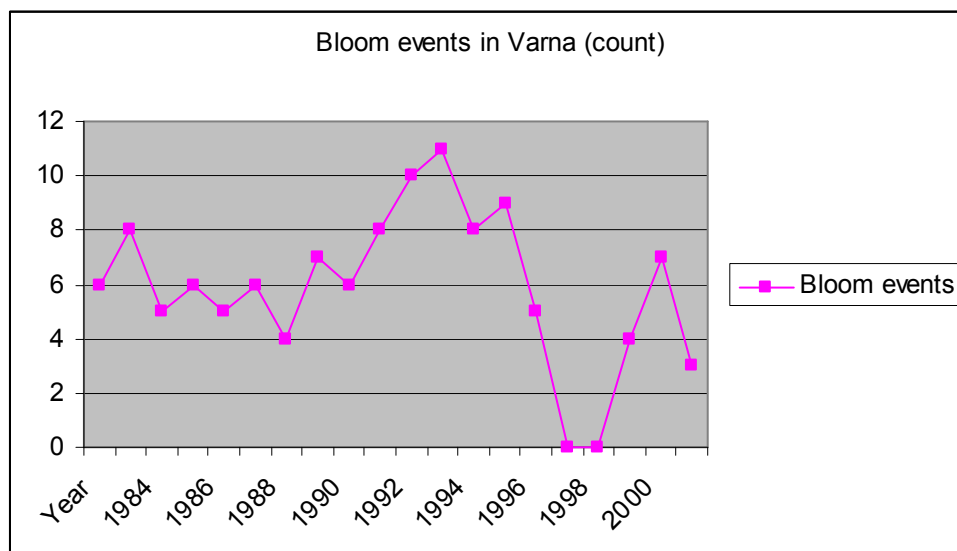


Source: Moncheva (2005)

The area of Varna Bay is not much influenced by the inputs from the Danube delta, due to prevailing currents, the major sources of nutrient inputs are from the watershed around Varna itself. As noted above, there have been frequent occurrences of algal bloom in the Varna area. Figure 3 gives an indication of the frequency of algal bloom events in Varna. It can be seen that the dynamics of the frequency of bloom events may have changed over time, but the causal factors are difficult to identify. One factor may have been political changes in this period, affecting nutrient inflows. Important sources of nutrients include waste water treatment, hotels, industry and agriculture.

In any case, algal blooms are a significant issue in the Varna Bay area and indeed along the Black Sea coast. It affects a number of activities, including recreational activity – which is the focus of this paper.

Figure 3: Bloom events in Varna (1982-2002)



Source: Based on Moncheva (2006)

Previous valuation studies on eutrophication and algal bloom in marine environments

Contingent valuation studies have been conducted on eutrophication in a number of locations. The Baltic Sea has been the focal point of several studies, including a study where the same contingent valuation study was implemented in Sweden (see Soderqvist, 1995) and Poland (see Markowska and Zylicz, 1996). In both cases, the questionnaire included: questions on how people use the Baltic Sea, information on eutrophication and its effects, questions on peoples' knowledge of these effects, a description of the valuation scenario and the WTP questions. A dichotomous choice format was employed, in which respondents were confronted with the following question: "If there were a referendum in Sweden (Poland) about whether to launch the action plan or not, would you vote for or against the action plan if your environmental tax would amount to SEK [X] per year during the 20 years?" Seven different amounts for X were randomly used in the question. The surveys measured changes in Total Economic Value – i.e. direct use plus indirect use plus non-use (Soderqvist, 1995). Both surveys were designed as mail questionnaires. The Swedish survey was sent to 600 randomly selected adults, of which about 60 percent responded. Likewise, the Polish survey was sent to 600 randomly selected adults yielding a 50 percent response rate. The mean annual WTP of Swedish respondents were about €726.90 per adult (or €406.57 if non-respondents to the survey are assumed to have a zero WTP). (Gren et al (1995) suggest rounding the figures down to¹ €677.61 and €369.61 per adult to

¹ Unconverted figures are SEK 5500 from SEK 5900 and SEK 3300 to SEK 3000 respectively.

reflect the fact that an open-ended WTP survey, undertaken as part of the same overall study, resulted in much lower estimates of mean WTP.) Mean annual WTP per Polish adult was €102.92 (or €52.69 if non-respondents to the survey are assumed to have a zero WTP).

In a separate exercise Sandstrom (1996) used a random utility maximization (RUM) model of Swedish seaside recreation to estimate the benefits (damages avoided) from reduced eutrophication of seas around Sweden. Sight depth data from around the Swedish coast was used as an indicator of water quality related to eutrophication. Sight depth is a good measure for at least two reasons. First, it is thought to be directly related to the recreationist's perception of water quality. Second, sight depth is highly correlated with nutrient load; an increase in the content of nutrients reduces the transparency of water.

By including the sight depth variable in the RUM model, consumer surplus becomes a function of, amongst other things, the level of eutrophication in Swedish coastal waters. In order to link the sight depth variable with nutrient loading, a relationship was estimated between sight depth and concentrations of total phosphorus (TP) and total nitrogen (TN). Sandstrom found that a 1 percent reduction in nitrogen content improved sight depth by 0.63 percent; a 1 percent reduction in phosphorus content increased sight depth by 0.18 percent. It is then possible to measure the benefits of policies to reduce TN and TP, in terms of increases in consumer surplus. The benefits of a 50 percent reduction in nutrient loading along the entire Swedish coastline was estimated to range between €29.6 million and €66.5 million, depending on the model specification used (between €17.25 and €38.81 per trip). It should be noted that these damage estimates do not capture all the impacts related to eutrophication. Other forms of use value – e.g. commercial fishing – and non-use value are not included. Also, data on one-day trips were not used; since several Swedish cities are on the coast, the omission of day trips could possibly underestimate the values significantly.

Le Goffe (1995) also investigated the costs of eutrophication, using a contingent valuation study to measure the benefits of reducing eutrophication in coastal waters near Brest, France. The survey, which was administered to over 600 Brest residents, elicited information for two goods: local pollution problems from microbes (including bathing and shellfish impacts) and local pollution from high concentrations of nutrients in the harbour and its consequences on the marine ecosystem.

The respondents were asked their maximum WTP to be able, without risk, to bathe and to consume wild shellfish in the harbour bay area. This question defined the good “salubrity”. Respondents were also asked their maximum annual WTP to prevent the asphyxiation of the harbour waters from high concentrations of nutrients. This question defines the good “ecosystem”. The average WTP was €38.90 and €28.95 per household per year, respectively, for the goods “salubrity” and “ecosystem”. The WTP figure for “salubrity” represents 10 percent of the annual water bill of residents (which was the payment vehicle used in the survey). No information was given on the physical benefit (e.g. improvement on water clarity) which was valued. Again, the welfare gains cannot be related to a specific change in nutrient loading.

Stolte et al (2003) investigated how Harmful Organic Blooms (HABs) impact on tourism in Europe. The authors conducted a contingent valuation exercise in 4

locations: Riccione (Italy), Galway (Ireland), Hanko (Finland), and Hyères, Les Pradet and Corquianne (France). They sampled 780 individuals over all the locations during the months of June, July and August. In the four locations, they investigated tourists experience with problems caused by algal blooms and their willingness to pay to mitigate the associated problems. Using a one and half-bounded dichotomous choice format², they asked respondents if they would be willing to pay a tax to finance investment that would prevent algal blooms from forming. When analysing each location separately, the authors found the HAB impact on tourism to be between 0.92 and 4.9 million Euro per year in Riccione (Italy), between 9.0 and 16.4 million Euro per year in Galway (Ireland), between 85 and 539 thousands Euros per year in Hanko (Finland), and between 4 thousands and 442 thousands Euros per year in Le Pradet, Hyères and Corquianne (France). However, the authors found that WTP is insensitive to previous experience and contact with algal blooms, though WTP is sensitive when all sites are analysed together. The authors point out that because the survey data is derived only from summer months, it is not necessarily a representative sample of the total visitor population, and therefore these results are not suitable for benefits transfer purposes. This is perhaps compounded by the low sample size relative to the number of locations studied.

To our knowledge, choice experiments have not been previously applied to the case of algal blooms in coastal waters. They have been applied in riverine systems (e.g. Hanley, Wright and Alvarez-Farizo, 2007) , in coastal areas for tourist preferences for different beaches (Brau and Cao, 2006), and in identifying preferences for improved coastal water quality improvements (Eggert and Olsson, 2003). In the next section we present an overview of the methodology, before applying it to the algal bloom case in Bulgaria.

Application of Conjoint Choice Experiments

A useful tool to assess the monetary valuation of thresholds effects is provided by the conjoint choice experiments technique.³ Such analyses are also known in the

² Respondents are asked if they would pay X, if yes they are asked if they would pay 50% more, if no they are asked if they would pay 50% less.

³ Choice experiments and other stated-preference (SP) techniques have recently emerged as a complement to revealed-preference (RP) techniques. While RP evaluate economic agents' behaviours in real markets, SP involve choice responses evoked in hypothetical markets. The interest in hypothetical behaviour in economics arises from different reasons, such as the necessity to investigate economic agents' preferences for new policies that might be implemented, for the development of a new product or good, or for evaluating goods that are not traded in real economic markets. All these examples make it clear that it is not possible to estimate agents' preferences using revealed preferences. Choice experiments analysis allows a great deal of flexibility because researchers can explore how a change in the hypothetical scenario influences people's responses, and compare the current scenario with many hypothetical alternatives. This is particular helpful for informing policy decisions before the policy itself has been decided upon.

Usually revealed preference data from regular marketplaces (such as the labour and the housing market) contain information about actual market equilibria for the behaviour of interest, and can be used to infer short-term departures from the current equilibria. In contrast, stated-preference data like responses to choice experiments questions are especially rich in attribute trade-off information. Therefore, stated-preference data are useful in estimating future changes in agents' behaviour (Louviere et al., 2000).

In a single choice experiment exercise researchers learn only which alternative is the most preferred, but the result of the exercise does not tell anything about the preferences for the options that have not been chosen. A single choice experiment exercise does not offer a complete preference ordering.

literature as conjoint choice analysis or choice experiments. In a typical conjoint choice survey, respondents are shown various alternative representations of a good, which are described by a set of attributes, and are asked to choose the most preferred (Hanley et al., 2001). The alternatives differ from one another in the *levels* taken by two or more of the *attributes*. This approach has the advantage of simulating real market situations, where consumers face two or more goods characterized by similar attributes, but different levels of these attributes, and are asked to choose whether to buy one of the goods or none of them.

To motivate the statistical analysis of the responses to conjoint choice experiment questions, it is assumed that the choice between the alternatives is driven by the respondent's underlying utility. The respondent's indirect utility is broken down into two components. The first component is deterministic, and is a function of the attributes of alternatives, characteristics of the individuals, and a set of unknown parameters, while the second component is an error term. Formally (see Alberini et al, 2007),

$$(1) \quad V_{ij} = \bar{V}(\mathbf{x}_{ij}, \boldsymbol{\beta}) + \varepsilon_{ij}$$

where the subscript i denotes the respondent, the subscript j denotes the alternative, \mathbf{x} is the vector of attributes that vary across alternatives (or across alternatives *and* individuals), and ε is an error term that captures individual- and alternative-specific factors that influence utility, but are not observable to the researcher. Equation (1) describes the random utility model (RUM).

Respondents are shown two or more representations of the good. The alternative they select is the one that gives them the highest utility. Because the observed outcome of each choice task is the selection of one out of K alternatives, the appropriate econometric model is a discrete choice model expressing the probability that alternative k is chosen. Formally, the probability that respondent i chooses alternative k is given by:

$$(2) \quad \Pr(k \text{ is chosen}) = \Pr(V_k > V_1, V_k > V_2, \dots, V_k > V_K) = \Pr(V_k > V_j) \quad \forall j \neq k,$$

If the error terms ε in (1) are independent and identically distributed and follow a standard type I extreme value distribution, it can be shown (Train, 2003) that the probability that respondent i picks alternative k out of K alternatives is:

$$(3) \quad \Pr(k) = \frac{\exp(\mathbf{w}_{ik} \boldsymbol{\beta})}{\sum_{j=1}^K \exp(\mathbf{w}_{ij} \boldsymbol{\beta})}$$

Where \mathbf{w}_{ij} is the vector of all attributes of alternative j . Equation (3) is the contribution to the likelihood in a conditional logit model. The full log likelihood function of the conditional logit model is

$$(4) \quad \log L = \sum_{i=1}^n \sum_{k=1}^K y_{ik} \cdot \log \Pr(i \text{ chooses } k),$$

Therefore, if researchers want to know a complete ordering of preferences it is necessary either to ask a respondent to do many choice exercises, or to survey more respondents varying the levels of the attributes.

where y_{ik} is a binary indicator that takes on a value of 1 if the respondent selects alternative k , and 0 otherwise, and $\Pr(i \text{ chooses } k)$ is equal to $\Pr(k)$ in equation (3).

For large samples and assuming that the model is correctly specified, the maximum likelihood estimates $\hat{\beta}$ are normally distributed around the true vector of parameters β , and the asymptotic variance-covariance matrix, Ω , is the inverse of the Fisher information matrix.

Once model (4) is estimated, the rate of trade-off between any two attributes is the ratio of their respective β coefficients. The marginal value of attribute l is computed as the negative of the coefficient on that attribute, divided by the coefficient on the price or cost variable:

$$(5) \quad MP_l = -\frac{\hat{\beta}_l}{\hat{\beta}_2}.$$

The willingness to pay for a commodity is computed as:

$$(6) \quad WTP_i = -\frac{\mathbf{x}_i \hat{\boldsymbol{\beta}}}{\hat{\beta}_2},$$

where \mathbf{x} is the vector of attributes describing the commodity assigned to individual i . It should be kept in mind that a proper WTP can only be computed if the choice set for at least some of the choice sets faced by the individuals contains the “status quo” (in which no commodity is acquired, and the cost is zero).

The conditional logit model described by equations (1)-(6) is easily amended to allow for heterogeneity among the respondents. Specifically, one can form interaction terms between individual characteristics, such as age, gender, education, etc., and all or some of the attributes, and enter these interactions in the indirect utility function.

Whether or not interaction terms are included, implicit in the conditional logit model is the assumption of Independence of Irrelevant Alternatives (IIA), which states that the ratio of the odds of choosing any two alternatives depends only on the attributes of the alternatives being compared, and is not affected by the attributes of other alternatives. Formally,

$$(7) \quad \frac{\Pr(k)}{\Pr(h)} = \frac{\exp(\mathbf{w}_{ik} \boldsymbol{\beta}) / \sum_j \exp(\mathbf{w}_{ij} \boldsymbol{\beta})}{\exp(\mathbf{w}_{ih} \boldsymbol{\beta}) / \sum_j \exp(\mathbf{w}_{ij} \boldsymbol{\beta})} = \frac{\exp(\mathbf{w}_{ik} \boldsymbol{\beta})}{\exp(\mathbf{w}_{ih} \boldsymbol{\beta})}.$$

An implication of the IIA is that, as shown in equation (7), adding another alternative, or changing the characteristics of a third alternative, does not affect the relative odds between alternative k and h . IIA generally imposes restrictive substitution patterns among the alternatives. A change in the attributes of one alternative, therefore, changes the probabilities of the other alternatives proportionately to satisfy the conditional logit’s requirement that the ratio of these probabilities remains the same (Train, 1999). This implies that the conditional logit is not well suited for alternatives that individuals perceive as close substitutes of one another.⁴ Researchers are thus

⁴ An example of a situation where the IIA would not be plausible is the blue bus/red bus example due to McFadden (1974). Consider commuters initially choosing between two modes of transportation, car and red bus. Suppose that a consumer chooses between the car and bus with equal probability, 0.5, so that the ratio in equation (16) is one. Now suppose a third mode, blue bus, is added. Assuming bus

advised to test for violations of this assumption using the appropriate Hausman test, and to consider models that relax it, such as the multinomial probit and mixed logit models.

Design of Questionnaire

In order to elicit the preferences of individuals for a reduction in algal bloom a questionnaire was designed using the choice experiment approach outlined above. Focus groups and pretesting were used to test the questionnaire and to identify appropriate payment vehicles and levels for the payment⁵.

The structure of the questionnaire was as follows⁶. First, the respondents were asked about their use of beaches, including general length of stay at the beach, what they did at the beach, who traveled with them and the importance they placed on various attributes in choosing which of the beach resorts to visit (including environmental attributes). The respondents were then informed about the algal bloom issue in the Varna Bay area and asked whether they had experienced a bloom episode and whether the bloom could affect their activities at the beach.

The questionnaire then turned to issues relating to policy options to reduce algal bloom. A description of the impacts of algal blooms was provided – with clarity of water being the major impact in Varna. The fact that algal bloom in the Varna case is not harmful to health was explicitly mentioned to reduce bias due to perception of a possible health risk. A policy scenario was presented, with the payment vehicle being a one off tax. The wording of the payment vehicle was as follows:

“The government is currently assessing ways of reducing the algal blooms in Varna Bay. Possible options include, for example, projects for the improvement of wastewater treatment in the region of Varna.

All the projects under consideration aim to reduce the **intensity** and the **duration** of the algal blooms. They have proven to be effective at other beaches, and are currently under consideration in Spain and Belgium as well.

However, these projects cost **money**. The current budget of the government could cover part of the costs, such as the maintenance of the cleanup measures. However, given the limited budget, the remaining part of the costs to allow the program to start

commuters do not care about the colour of the bus, consumers will choose between these with equal probability. But then IIA implies that the probability of each mode is 1/3; therefore, the fraction of commuters taking a car would fall from 1/2 to 1/3, a result that is not very realistic. While this example is admittedly extreme (in practice, one would group the blue bus and red bus into the same category), it indicates that the IIA property can impose unwanted restrictions in the conditional logit model (Wooldridge, 2002).

⁵ It should be noted that this questionnaire was designed alongside two others - for Mallorca and the Belgian coastal zone (see Torres et al, 2007 and Longo et al, 2006). The intention was that these surveys would be subject to benefit-transfer testing (see Barton et al, 2008). These considerations meant that the surveys were designed to be as comparable as possible to each other..

⁶ A copy of the questionnaire is available on request.

will be covered with a one time tax that each household in Varna will have to pay next year (and next year only).

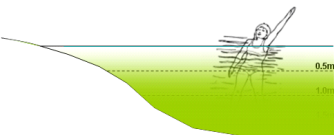
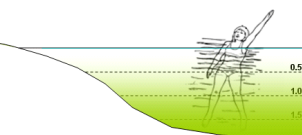
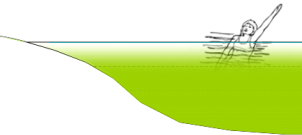



The amount of the one time tax varies from one project to the next. The projects' efficiency in reducing the quantity and the duration of the algal blooms also differ. And we have reasons to suspect that some of the projects may influence the number of people who come to the beach.

So in the next few questions, we will describe the expected impacts of some of the projects based on these characteristics. And we will ask you to tell us which one you would prefer, between two potential projects and the current situation.”

A series of four choice sets was then presented to each respondent. In total there were 28 choice sets used (in 7 different sets). An example is given below in Figure 4. A full set of the choice cards are available on request. The attributes chosen were visibility – the depth to which it would be possible to see into the water during a bloom event, the duration, congestion and the charge. A “no project” scenario was given as an alternative with no charge being applied. For visibility a figure swimming was shown with a visual representation using colour shading to enable respondents to see the impacts. This representation was the result of lengthy discussions among the study team – initially it was thought that photos could be used but the differences in heights of individuals meant that a pictorial representation using line drawings would be more appropriate. For duration, different durations of the bloom were set – the link between amount (indicated by the visibility) and duration of bloom was felt by the focus groups and the pretests to be potentially uncorrelated and so this enabled the questionnaire to include this as a separate attribute. For congestion, a photo of a beach was manipulated to allow a visual representation of a given density of people at a beach. The colour of the bloom used in the visibility attribute was decided upon in consultation with scientists in Varna.

Figure 4: Example Choice Set for Algal Bloom Prevention in Varna

Choice Set 4

	Project G	Project H	No Project
Visibility			
Duration	You cannot see beyond your knees (1 m deep) 4 weeks	You cannot see beyond your feet (1.5 m deep) 6 weeks	You cannot usually see beyond your waist (0.5 m deep) Usually 6 weeks
Congestion	 The nearest person (or group of people) is more than 30 m away from you	 The nearest person (or group of people) is more than 30 m away from you	 The nearest person (or group of people) is between 3 and 30 m away from you
Price	35 leva	50 leva	0 leva

Results

Descriptive statistics

Our first order of business is to explore the characteristics of the sample of the Bulgarian residents interviewed. Tables 1 and 2 report the descriptive statistics of our sample. Our sample is quite balanced in terms of gender, is well educated, has an average net monthly household income of 605 Leva. Of the 71% of people who know their water bill, they pay an average annual water bill of 128 Leva. About 81% of the respondents have a job, 8% are retired, about 9% are students, 2% is homemaker, and only about 3% are unemployed. Quite surprisingly, the average number of children within a household is less than one.

When we look at the attitudes of our respondents towards recreational activities at the beach, Tables 1 and 2 show that people spend an average of 2.5 weeks at the beach every year and on the average trip they stay about 2.5 hours. Respondents average travel time to the beach is quite short, only about 24 minutes, as almost all respondents (98%) living in Varna. Most respondents travel by car (68%), but also bus and walking are used by about one third of respondents respectively.⁷ Among the favourite activities at the beach, our respondents like sunbathing (85%), swimming (77%), walking along the beach (36%), and doing thalasso therapy (23%). Most people go to the beach with friends (66%) and family (49%), and only about 17% and 16% respectively go on their own or with a partner. Among the factors affecting the decision to go to the beach, the water quality and the cleanliness of the beach are important elements for about 70% of the respondents, while crowding, quality of the services, access and family tradition play minor roles in respondents' choices. It is remarkable that almost 90% of the respondents have seen algal blooms at the beach, but their presence has affected the recreational experience of only 40% of the respondents.

Choice experiments questions

⁷ The total does not sum to 100 because some respondents use more than one travel mode. Only 5 respondents use a moped, and 24 a bicycle.

Before we analyzed our choice experiment questions we checked the quality of the answers. Before asking the choice questions, only about 6% of the respondents asked the enumerator to repeat the description of the program, suggesting that our questionnaire was quite clear. In addition, after the choice questions, the questionnaire presented a series of debriefing questions to disentangle respondents who failed to understand the choice exercise, answered strategically, or found the questions too difficult.

Most respondents found the choice exercise quite easy: on a 1 to 5 Likert scale question about the difficulty of the choice exercise, where 1 means very easy and 5 very difficult, the average answer was 1.92. About 70% of the respondents gave equal weight to each attribute, while about 20% gave more importance to the cost attribute and few respondents gave more importance to the other attributes.⁸ We further asked respondents to rank the importance of the attributes in the choice questions, and the results show that they gave a similar importance to the presence and the duration of the algal bloom, followed by the cost, whilst the crowding at the beach is the least important attribute. About 23% of the respondents always chose the status quo, and, among these, the reasons to vote against the proposed policies were justified by the already high expenses the household faces for 47% of them, the already high taxes for 29% of them, the doubt in the usefulness of the program for 28% of them, the unremarkable nuisance caused by the algae for 27% of them, and other reasons for 6% of them.⁹ Finally, at the end of the questionnaire, the enumerators reported some notes about the quality of the interview. According to the interviewers, about 97% of the respondents understood the choice exercise, only about 5% were annoyed or very annoyed during the interview, and generally the interviews had no interruptions caused by lack of understanding, annoyance, or other reasons. This first analysis of the data allows us to conclude that the questionnaire was well accepted by respondents, they engaged in the choice questions, and did not show significant protest behaviours. We therefore ran our econometric models with the full sample of observations.

⁸ We deem this latter result as encouraging, as many observers have suggested that in choice experiments respondents overlook the price attribute. Indeed our results do show that price is one of the most important attribute.

⁹ The total does not sum to 100 because respondents could volunteer more than one answer.

Table 1: Descriptive Statistics: Dummy variables

Variable name	Description	N	Mean	Std Dev
Travel Mode				
Q7_1	Travel by bus	850	0.30	0.46
Q7_2	Travel by car	850	0.68	0.47
Q7_6	Travel by foot	850	0.30	0.46
Activities at the beach				
Q9_1	Goes swimming	850	0.77	0.42
Walking	Any type of walking	850	0.36	0.48
Q9_6	Sunbathing	850	0.85	0.36
Q9_14	Does Thalasso therapy	850	0.23	0.42
People at the beach with				
Q10_1	Goes with family	850	0.49	0.50
Q10_2	Goes with friends	850	0.66	0.47
Q10_3	Goes with partner	850	0.16	0.36
Q10_4	Goes on his/her own	850	0.17	0.37
Ranking of attributes				
Crowdveryimport	Crowd is very important	826	0.41	0.49
Accessveryimport	Access is very important	836	0.41	0.49
Distnoimport	Distance to the beach is not important	830	0.62	0.49
Waterveryimport	Water quality is very important	835	0.68	0.47
Cleanveryimport	Cleanliness at the beach is very important	836	0.70	0.46
Facilnoimport	Facilities at the beach are very important	830	0.40	0.49
Habitnoimport	Family tradition is not important when deciding a beach	822	0.65	0.48
Experience and perception of algal bloom events				
Q12	Has been at the beach with algal blooms	850	0.87	0.34
Q13	Algae affect recreation experience	849	0.40	0.49
Scenario understanding				
Q14	Repeated scenario description	850	0.06	0.24
Q15_1	Knows the water bill	850	0.71	0.45
Q17_1	Considered all attributes in the choice experiment	850	0.67	0.47
Q17_2	More importance to visibility in the choice experiment	850	0.04	0.20
Q17_3	More importance to duration in the choice experiment	850	0.03	0.18
Q17_4	More importance to number of people in the choice experiment	850	0.04	0.18
Q17_5	More importance to cost in the choice experiment	850	0.22	0.42
Swimming Thresholds				
Q20A	Would bathe at 0.2m visibility (chest)	850	0.06	0.23
Q20B	Would bathe at 0.5m visibility (waist)	850	0.08	0.27
Q20C	Would bathe at 01m visibility (knees)	850	0.28	0.45
Q20D	Would bathe at 1.5m visibility (feet)	850	0.70	0.46
Q20E	Would bathe at 3m visibility (bottom)	850	0.80	0.40
Depth	Looked at the depth indicated in the question and the picture	849	0.29	0.45
Green	Looked at the choice of colour (green) of the algae bloom illustration	849	0.53	0.50
Bottom	Looked at the intensity of the colour at the bottom	849	0.17	0.38
Reasons for choice of status quo in every choice set				
Q19_1	Cannot afford any additional expenses	192	0.47	0.50
Q19_2	Already pay enough taxes	192	0.29	0.46
Q19_3	No trust in the usefulness of the policies	192	0.28	0.45
Q19_4	algal blooms are not a very important problem	192	0.27	0.44

Q19_5	other reason for voting always no	192	0.06	0.24
Socioeconomic Variables				
Q22	Male	850	0.48	0.50
Q25_1	full time worker	850	0.63	0.48
Q25_2	Employed part time	850	0.09	0.29
Q25_3	Self-employed	850	0.09	0.28
Q25_4	Unemployed	850	0.03	0.17
Q25_5	Retired	850	0.08	0.27
Q25_6	Student	850	0.09	0.28
Q25_7	Looking after the home full time	850	0.02	0.15
Uniphd	University or PhD qualified	850	0.40	0.49
Debriefing questions to interviewer				
Q29	Respondent understanding according to the interviewer	850	0.97	0.16
ANNOY1	Annoyance level =1 (not annoyed)	850	0.38	0.48
ANNOY2	Annoyance level =2	850	0.47	0.50
ANNOY3	Annoyance level =3	850	0.10	0.30
ANNOY4	Annoyance level =4	850	0.03	0.18
ANNOY5	Annoyance level =5 (very annoyed)	850	0.02	0.14
If the survey stopped, it happened because the respondent...				
Q31_1	...did not understand the survey	850	0.00	0.00
Q31_2	...did not believe the survey	850	0.01	0.10
Q31_3	...was annoyed	850	0.00	0.06
Q31_4	...showed protest behaviour	850	0.00	0.06
Q31_5	...other	850	0.00	0.03

Table 2: Descriptive Statistics

Variable name	Description	N	Mean	Std Dev	Min	Max
Q4	Days at the beach in past 12 months	815	17.47	14.02	0	210
Time	Time at the beach (minutes)	819	147.18	120.80	30	420
Q8	Travel time	834	24.13	12.19	0	150
Q15_2	Water bill value (per year)	850	128.03	94.87	0	400
Q16	Perceived difficulty of choice exercise (1=very easy; 5=very difficult)	842	1.92	0.90	1	5
Q18_1	Visibility rank	825	2.18	1.11	1	4
Q18_2	Duration of algal bloom rank	826	2.54	0.99	1	4
Q18_3	Number of people at the beach rank	836	2.76	1.04	1	4
Q18_4	Amount of the tax rank	831	2.39	1.26	1	4
Age	Age	825	41.00	12.54	16	87
Q26_2	Children #	850	0.88	0.86	0	4
Q26_3	Children # living at home	850	0.58	0.81	0	4
Income	Net monthly household income (upper income was set at 1000)	839	605.15	252.60	100	1000
Q30	Annoyance level	850	1.85	0.89	0	5

In running the econometric models, we used two different ways to code the variables for the attributes. In a first set of models we used effect code dummy variables (see

Louviere et al, 2000) for the levels of the attributes of congestion and visibility. In a second set of models we used continuous variables for all our attributes. The attribute for the quantity of algal bloom (visibility) takes on three values: 0.5 - low visibility (status quo), 1 - medium visibility, and 1.5 metres - high visibility. The attribute for the duration of the algal bloom is measured in weeks and takes on values of 1 (status quo), 4, and 6 weeks. The levels for the attribute cost are 0 (status quo), 12, 25, 35, 50, 75, and 100 Leva. The attribute for the congestion at the beach, described as 'the nearest person is situated' within 3 meters, between 3 and 30 meters and beyond 30 meters, was coded as 1.5, 16.5 and 30 in the model with continuous variables, and low congestion, medium congestion and high congestion in the effects code dummies models.

Table 3 shows the results of three models that employ the effect code dummies for congestion and visibility. Model 1 is the basic model with the four attributes and the alternative specific constants. Model 2 adds an interaction terms between the two visibility dummies and the duration of the algal bloom as we expect that respondents may have considered the two attributes together. The third model further adds interaction terms with the Alternative Specific Constants (ASCs) and some socio-economic characteristics of the respondents. A likelihood ratio test (LR=225.88) shows that Model 3 outperforms Model 2.

The coefficients of the interaction terms suggest that our model is internally consistent: people with higher income, that have a high education degree, and that enjoy swimming at the beach are more likely to choose the hypothetical programs. Respondents that are full time employed and that live further away from the beach and therefore have less opportunities to visit the beach are less accepting of the hypothetical programs.

Quite surprisingly the number of days spent at the beach does not seem to have a significant effect on the choice of the hypothetical programs over the status quo. It is possible, however, that this effect may have been picked up by the interaction terms of the ASCs with full time worker and travel time.

The sign of the estimates of the attributes coefficients suggest that people prefer a medium level of congestion, compared to a low level of congestion and to a high level of congestion (the latter coefficient is calculated as the negative of the sum of the coefficients for low and medium congestion). It seems therefore that our respondents like when the beach is frequented by a medium number of people, while they do not like when almost no people or many people are at the beach. The positive sign of the coefficient for low congestion suggests however that our respondents would prefer few people at the beach compared to a high number of visitors.

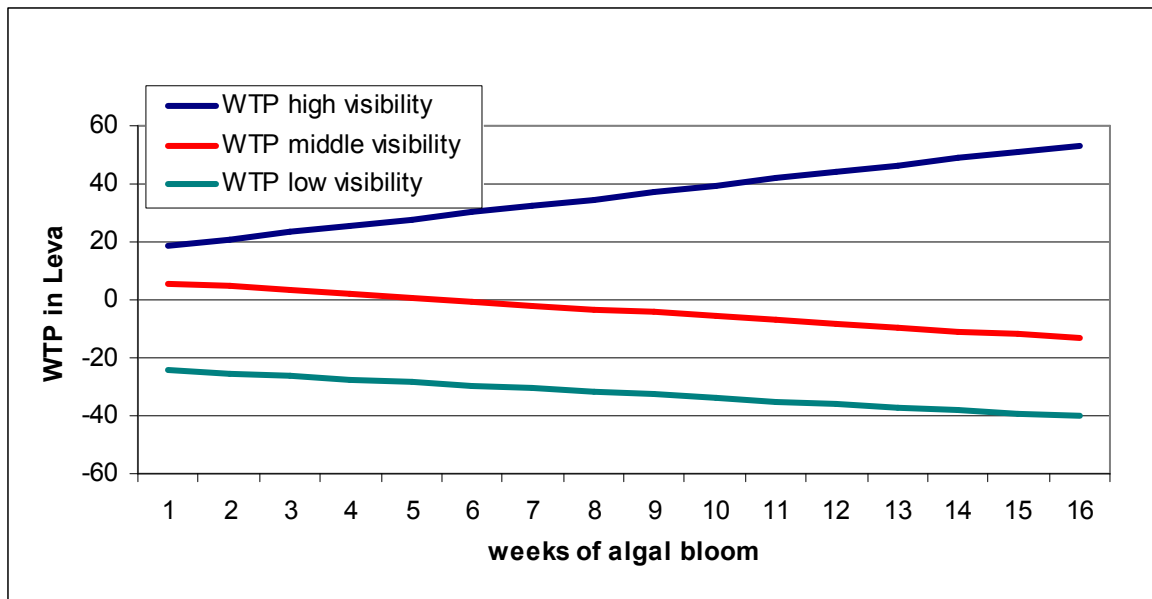
In terms of algal blooms, the negative and strongly significant sign of the coefficient of duration shows that respondents do not like a program that entails a long period of algal bloom. In terms of quantity of algae, respondents prefer programs that offer high visibility levels, compared to medium visibility levels. However, to have a clear understanding of the effects of the attributes on the choices, it is necessary to look at the interaction terms between the quantity of algae and the duration of the bloom. Figure 5 helps us analyzing this point. A first clear result from the figure is that our respondents are willing to pay more for programs that entail a high visibility

compared to programs offering low or medium visibility levels, independently by the number of weeks of algal bloom. When we look at the number of weeks, we can see that respondents' WTP increases for programs with high visibility, while it decreases and becomes negative (willingness to accept) for medium and low levels of visibility. This result suggests therefore that when comparing algal blooms lasting for 6 weeks, our respondents are willing to pay about 30 Leva for a program that offers high visibility levels, almost nothing for assuring a medium level of visibility and are willing to accept about 29 Leva when the level of visibility is low. These amounts of money are also the amounts that make our respondents indifferent among the three programs. One apparently surprising result from the figure is that WTP increases with number of weeks of algal bloom with high visibility. This result, however, should be interpreted considering that this WTP is relative to the other levels of visibility.

Table 3: Conditional logit model: Effect codes dummy variable models

Variable	Model 1		Model 2		Model 3	
	Coeff.	t-ratio	Coeff.	t-ratio	Coeff.	t-ratio
Cost	-0.0192	-16.78	-0.0187	-16.12	-0.0201	-16.28
Duration	-0.0758	-5.26	-0.0774	-5.08	-0.0869	-5.42
low congestion	0.0870	2.00	0.0699	1.58	0.0922	1.98
Medium congestion	0.2025	5.23	0.1978	5.09	0.2122	5.21
high visibility	0.5042	12.75	0.3464	3.98	0.3278	3.60
Medium visibility	0.0282	0.68	0.1360	1.56	0.1421	1.54
(high visibility)*(duration)			0.0417	1.97	0.0466	2.10
(medium visibility)*(duration)			-0.0279	-1.25	-0.0256	-1.08
ASC1	-0.4136	-4.58	-0.4647	-3.70	-1.2031	-5.57
ASC2	-0.3310	-3.51	-0.4149	-2.89	-1.3895	-6.06
(income)*(ASC1)					0.0015	7.66
(full time worker)*(ASC1)					-0.2140	-2.19
(uni or phd)*(ASC1)					0.3598	3.59
(travel time)*(ASC1)					-0.0117	-2.98
(dummy for swimming)*(ASC1)					0.2474	2.08
(days at the beach)*(ASC1)					-0.0019	-0.51
(income)*(ASC2)					0.0018	8.98
(full time worker)*(ASC2)					-0.1557	-1.60
(uni or phd)*(ASC2)					0.4786	4.83
(travel time)*(ASC2)					-0.0179	-4.40
(dummy for swimming)*(ASC2)					0.2871	2.42
(days at the beach)*(ASC2)					0.0024	0.77
Obs	3396		3396		3172	
Loglikelihood function	-3283.51		-3281.27		-2948.55	

Figure 5: WTP for different levels of visibility (model 3)



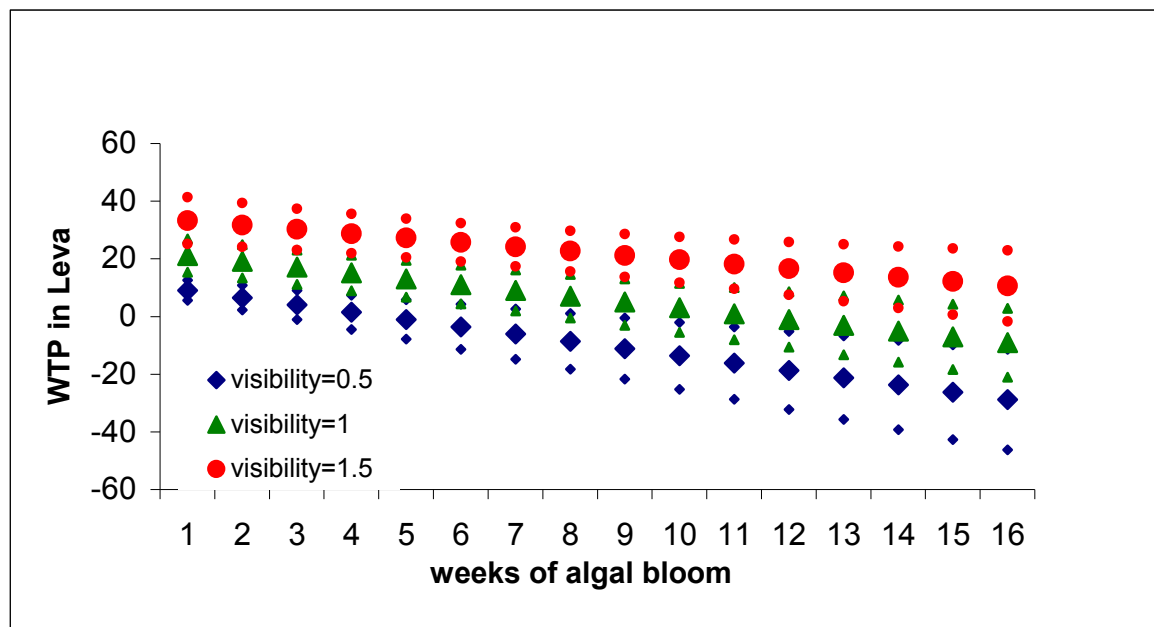
To better explore this result we run an additional model, Model 4, where we use continuous variables for visibility and congestion and run random parameters logit models (1,000 repetitions), to account for heterogeneity among respondents, assuming that all the standard deviations of the parameters are normally distributed. We also ran a model without the random parameters (not reported here), but found that the former outperformed the latter. Results of the random parameter logit model and WTP for different levels of visibility and duration of algal bloom are shown in Table 4 and Figure 6 respectively. The table shows that when we use continuous variables the effect of the interaction term between visibility and duration of algal bloom is not significant, even though the standard deviation of the parameter is. This result suggests that at least some respondents did not consider relevant the interaction between visibility and duration of the bloom. The table also reports a positive and significant sign for the coefficient of congestion, suggesting that programs that offer low congestion are preferred. The marginal price for one metre of extra space between the respondent and the nearest person is equal to 0.38 Leva. Figure 2 reports the WTP with confidence intervals calculated with the delta method. The figure shows that, as in Figure 3-5, respondents are willing to pay more for a program that entails high visibility levels compared to low and medium visibility levels, for any duration of algal bloom. However, differently from the previous figure, Figure 7 shows that respondents are willing to pay more for programs that offer shorter duration of algal bloom, for any visibility level, a result highly intuitive. Model 4 is therefore our preferred model. It shows that respondents are willing to pay for a program that entails 1 week of algal bloom about 33 Leva (s.e. 8.09) when there is high visibility; 21 Leva (s.e. 5.75) with medium visibility and 9 Leva (s.e. 3.48) with low visibility.

Table 4: Random Parameter logit model (1000 repetitions): continuous variables model

Variable	Model 4	t-stat
	Coefficient	

Cost	-0.0505	-5.35
Duration	-0.1530	-2.02
Visibility	1.1701	3.80
Congestion	0.0196	4.21
Visibility*duration	0.0512	0.72
ASC1	-0.0561	-0.27
ASC2	-0.0760	-0.36
Derived standard deviations of parameter distributions (normal distribution)		
NsCOST	0.0406	4.57
NsDURATION	0.1986	1.09
NsVISIBILITY	2.1102	3.36
NsCONGESTION	0.0013	0.09
NsVISIBILITY_DURATION	0.4014	3.41
Obs		3396
Loglikelihood function		-3269

Figure 6: WTP for different levels of visibility (model 4)



Conclusions

The consideration of threshold effects in policy analysis of marine systems requires the use of specific economic tools. This paper builds on the choice experiment approach to value the impact on recreational users in Varna Bay, Bulgaria.

Eutrophication is an important issue in the area around Varna Bay, with a number of occurrences of algal blooms in recent times.

A choice experiment approach was employed to elicit the value placed on algal blooms by residents in the Varna area. Focus groups and pretesting enabled the revision of the questionnaire. The advantage of the use of choice experiments in this case in valuing different attributes of the bloom (both visibility impairment and duration) is that it should facilitate better understanding of the way changes in bloom characteristics affect the values placed on them. In addition, with further studies, the potential for benefit transfer from these results is enhanced as different blooms with different impacts can be evaluated using such a methodology.

This paper shows that there are significant welfare losses from algal blooms. The key findings are:

- i) the amount of bloom is important: respondents are willing to pay for a program that entails 1 week of algal bloom about 33 Leva, or €17, when there is high visibility; 21 Leva, or €10.75, with medium visibility and 9 Leva, or €4.60, with low visibility;
- ii) Duration is important: respondents are willing to pay more for programs that offer shorter duration of algal bloom; and
- iii) Congestion of the beach may be significant: The marginal price for one metre of extra space between the respondent and the nearest person is equal to 0.38 Leva

These results are lower than those for the previous studies reported above, but it must be borne in mind that this study did not consider toxic algal blooms and was also based in Bulgaria. The attitudinal aspects of the survey show that respondents were more willing to swim in discoloured water than was the case in a similar study in Mallorca (Torres et al, 2007). To aggregate the above across the population of Varna suggests that if there were 1 week of bloom and a high level of visibility compared to the current situation then residents would be willing to pay €2.2 million for this¹⁰, which is not an insignificant sum, particularly bearing in mind we do not include the additional welfare costs of tourists and also other economic effects of the blooms.

Further work is needed to link the values to changes in nutrient levels, which is a difficult task given the complex nature of ecosystems. In addition, more similar studies could be conducted to facilitate benefit transfer tests, however given the relatively heterogeneous nature of blooms and social attitudes to them in different locations these may prove more difficult than is the case with other environmental issues.

It is important to be able to value algal blooms and other effects of nutrient inputs to riverine and coastal systems as policies are increasingly being put in place to reduce loadings (e.g. through the Water Framework Directive). Without knowing the values placed on blooms it may be difficult to evaluate the extent to which investments should be targeted to reducing bloom events, compared to other issues in the coastal

¹⁰ This takes the population of Varna is 357,270 and the average household size in Bulgaria as 2.7.

zone – for example beach cleaning or measures to improve accessibility to the coast. This study presents a first estimate for the value placed on reducing the impacts of algal bloom in the Bulgarian case.

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